

# Evaluation of the Accuracy of Event Data Recorders in Chrysler Vehicles in Frontal Crash Tests

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## **Abstract**

In recent years, major advances in field data collection and analysis have been achieved through the integration of real-world vehicle crash data captured by on-board, electronic, event data recorders (EDR's). To date, publicly-available data have been limited to just two manufacturers, namely General Motors and Ford. Recently, Chrysler has provided a tool by which researchers can access EDR's installed in their vehicles. The current study looks at the new crash data that are now available from Chrysler vehicles and explores the accuracy of this information. The study uses data from a series of staged collisions with EDR-equipped vehicles and compares data downloaded from these devices to equivalent information captured by laboratory instrumentation. Full-frontal crash tests, over a range of test speeds, and conducted on a number of different model vehicles, are used in the study.

## **Résumé**

Au cours des dernières années, d'importants progrès dans le domaine de la collecte et de l'analyse de données ont été faits grâce à l'intégration de données sur les accidents impliquant des véhicules réels qui ont été recueillies par des enregistreurs de données routières (EDR) électroniques et intégrés dans les véhicules. À ce jour, les données accessibles au public ont été limitées à deux fabricants : General Motors et Ford. Récemment, Chrysler a fourni un outil par lequel les chercheurs peuvent avoir accès aux EDR intégrés dans leurs véhicules. L'étude actuelle examine les nouvelles données sur les collisions qui sont maintenant disponibles à partir des véhicules Chrysler et explore l'exactitude de cette information. L'étude utilise des données tirées d'une série d'essais de collisions menés avec des véhicules équipés d'EDR et compare les données provenant des EDR à des données équivalentes provenant d'appareils de laboratoires. L'étude a mené des essais de collision frontale sur une gamme de vitesses d'essais et à l'aide d'un certain nombre de modèles différents de véhicules.

## Introduction

Event data recorders capture information about the status of various vehicle safety systems, such as seat belt use and air bag deployment; details of pre-crash driver actions such as inputs to the throttle and brake, and the nature of the crash pulse in the form of the vehicle's velocity change and/or acceleration time history. [1]

The objective collision data provided by EDR's have proven useful to a variety of interest groups, including automobile manufacturers, government regulators, safety researchers, law enforcement personnel, vehicle insurers, and the legal community. The data have allowed vehicle safety systems to be refined, vehicle regulations to be enhanced, safety-related defects to be identified and corrected, and have provided the basis for the resolution of court cases and insurance claims. [2]

General Motors Corporation (GM) pioneered the installation of EDR's in its vehicles, and was the first manufacturer to provide access to the data captured by these devices through a publicly-available crash data retrieval (CDR) tool. [3] In 2003, Ford Motor Company was the second manufacturer to adopt the CDR system for its EDR's. Subsequently, in 2008, Chrysler announced its use of the same tool for the EDR's in its vehicles.

In the present study, the crash pulses downloaded from a number of EDR-equipped Chrysler vehicles that were the subject of staged collisions are compared to equivalent data obtained from laboratory instrumentation used for the crash tests.

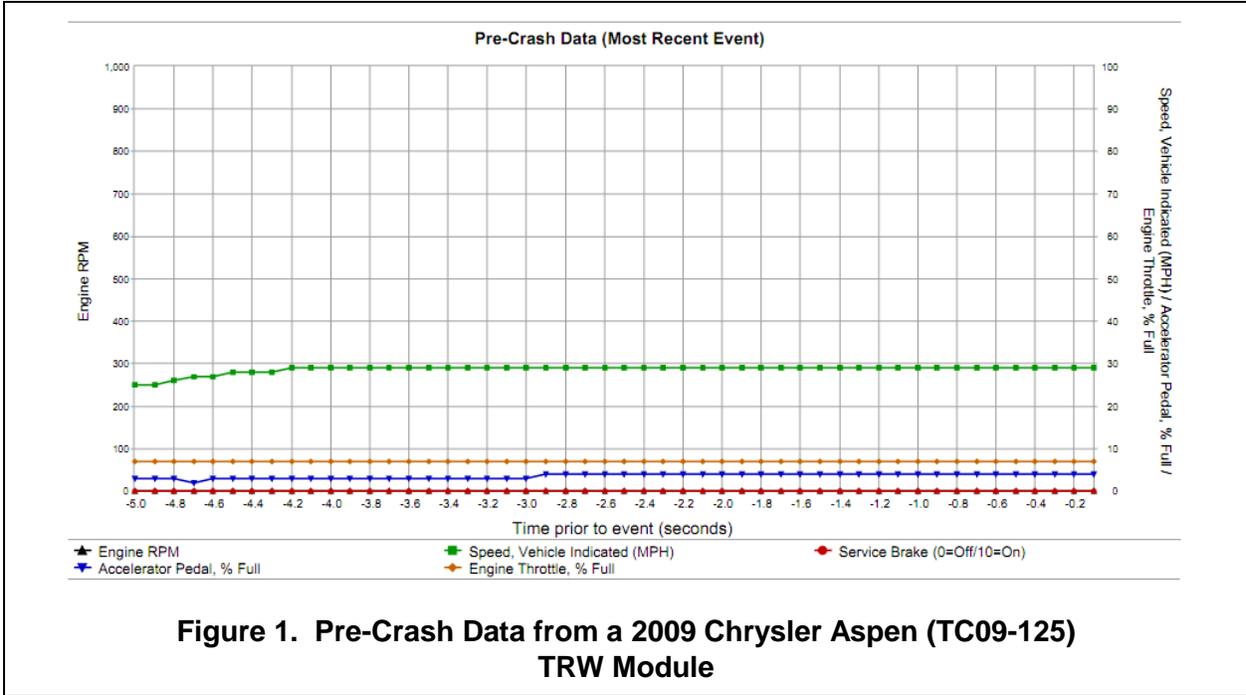
Similar research conducted on General Motors' vehicles has been reported previously [4], while other prior work has included both GM and Toyota vehicles. [5,6].

Earlier work on Chrysler vehicles equipped with EDR's has been limited to evaluations of some of the pre-crash data elements, such as vehicle speed, brake and throttle application, and steering wheel angle. [7,8]

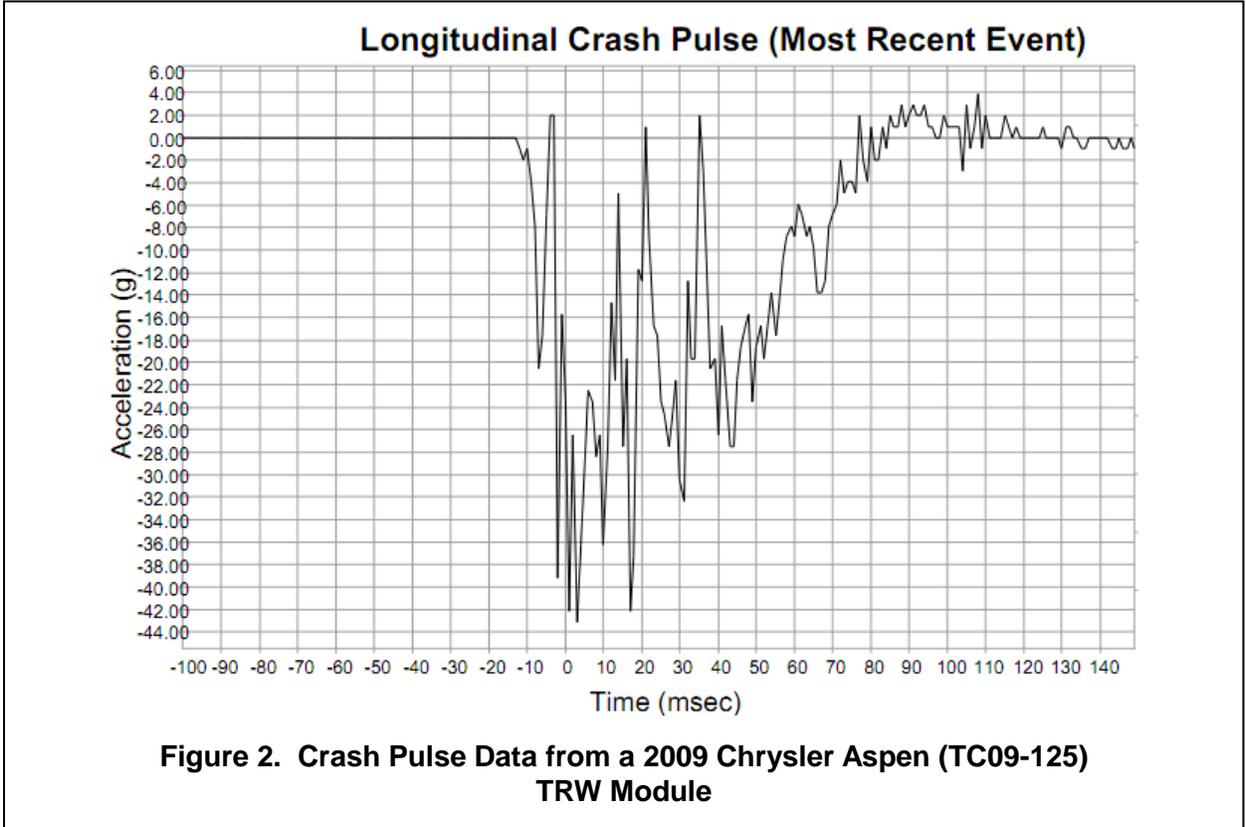
## Chrysler Event Data Recorders

EDR modules from both TRW Automotive and Continental Corporation are used in various models of Chrysler vehicles. While these EDR's generally capture a similar range of pre-crash and crash-phase data elements there are some significant differences.

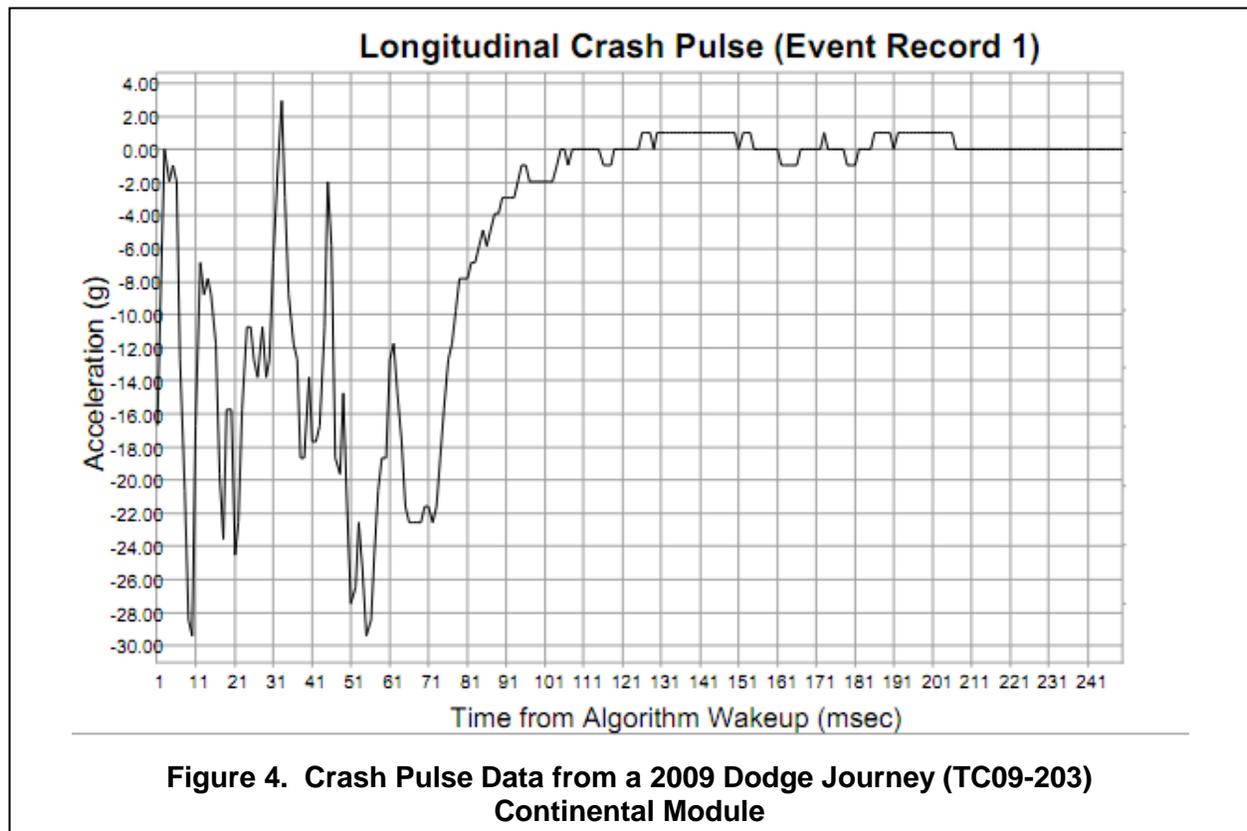
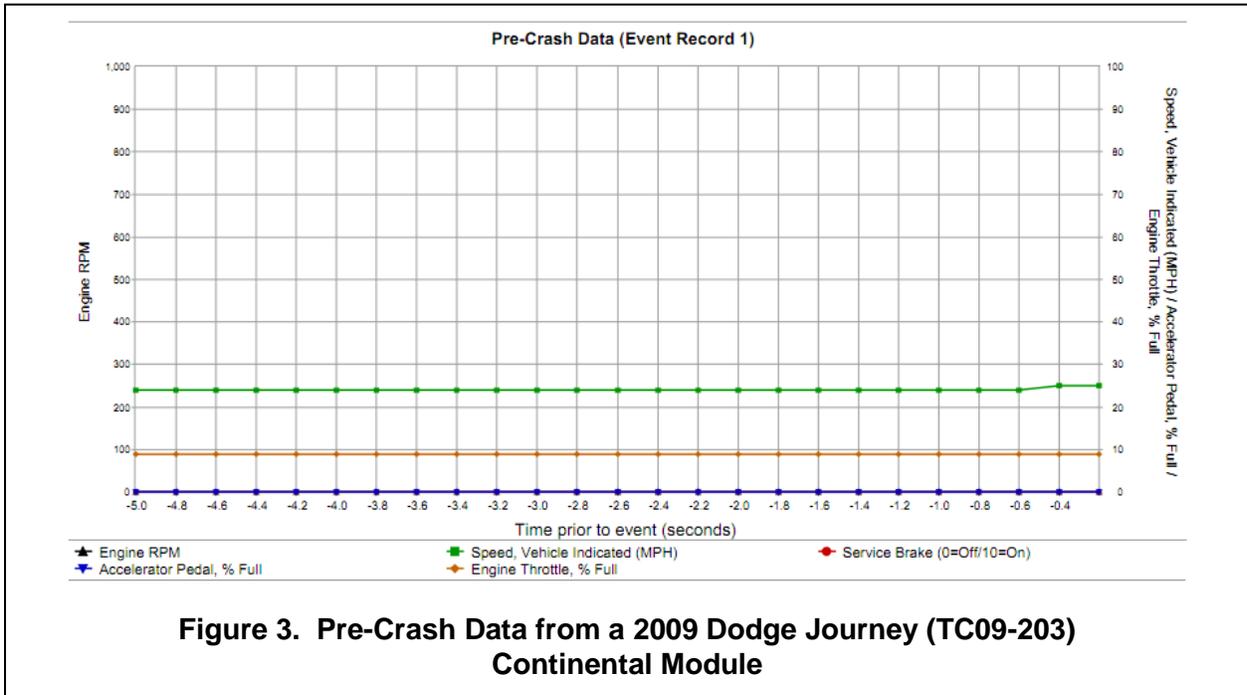
The reports produced for both types of modules include identification data such as the original Vehicle Identification Number (VIN) and the serial number of the air bag control module, in addition to user-entered data such as the investigator's name, case number, and collision date. A range of system configuration codes indicates the availability of vehicle features such as seat belt pre-tensioners and head curtain air bags.



**Figure 1. Pre-Crash Data from a 2009 Chrysler Aspen (TC09-125) TRW Module**



**Figure 2. Crash Pulse Data from a 2009 Chrysler Aspen (TC09-125) TRW Module**



The TRW module provides pre-crash data at 0.1 second intervals over a period of five seconds for a range of data elements that include: vehicle speed (mph and km/h), engine speed (RPM), accelerator pedal and engine throttle position (%), and brake application (on or off). The Continental module provides these same data elements, but at 0.2 second intervals.

A chart of the above-noted data from the EDR in a 2009 Chrysler Aspen (TRW module) is shown in Figure 1. Note that these data result from a nominal 48 km/h (30 mph) frontal crash test. The vehicle was winched into impact with a rigid barrier, rather than travelling under its own power. In consequence, only the vehicle speed data (green line) are relevant in this instance.

A chart of the equivalent pre-crash data from a 2009 Dodge Journey (Continental module) is shown in Figure 3. The nominal test speed for this crash test was 40 km/h (25 mph).

Both systems record the crash pulse as the vehicle's acceleration profile with respect to time. The TRW module provides longitudinal acceleration (g) in one millisecond increments for approximately 100 ms before a nominal time-zero, and subsequently for a further 150 ms (see Figure 2). Although not specified on the graphs, it appears that time-zero is anchored on the time at which the air bag control module commands deployment of a pyrotechnic device, i.e. an air bag or a seat belt pre-tensioner.

The Continental module provides both longitudinal and lateral accelerations in one millisecond increments for 250 ms following algorithm wakeup (see Figure 4).

Test Number	Test Vehicle	Test Protocol	Test Speed (km/h)	EDR Module Manufacturer
TC09-203	2009 Dodge Journey	FFRB(40)	40.19	Continental
TC09-126	2009 Dodge Journey	FFRB(48)	47.90	Continental
TC07-218	2007 Jeep Compass	FFRB(48)	47.84	TRW
TC07-116	2007 Jeep Compass	FFRB(56)	56.12	TRW
TC08-131	2008 Dodge Avenger	FFRB(48)	47.80	TRW
TC09-125	2009 Chrysler Aspen	FFRB(48)	47.69	TRW
TC09-127	2009 Dodge Ram	FFRB(48)	47.66	TRW

**Figure 5. Crash Test Matrix**

## Crash Test Methodology

Vehicle acceleration data were obtained from a series of staged collisions conducted by Transport Canada that involved Chrysler vehicles equipped with event data recorders. Five vehicle models were used for the present work, the 2007 Jeep Compass, 2008 Dodge Avenger, and the 2009 Chrysler Aspen, Dodge Journey and Dodge Ram. Full frontal rigid barrier (FFRB) crash tests were conducted at speeds of 40, 48 or 56 km/h. In Figure 5, these tests are designated as FFRB(40), FFRB(48) and FFRB(56), respectively.



**Figure 6. 2007 Jeep Compass  
(TC07-116)**



**Figure 7. 2009 Chrysler Aspen  
(TC09-125)**

The instrumentation used for the staged collisions conducted at Transport Canada's Motor Vehicle Test Centre included accelerometers with a sampling frequency of 10 kHz. The test vehicle was instrumented with several such accelerometers, the most relevant of which, for the present purposes, were units mounted on the floor at the base of the left and right B-pillars, and on the central tunnel, at the vehicle's centre of gravity. These three accelerometers were in the closest proximity to the vehicle's original-equipment event data recorder.

A tape switch mounted on the vehicle's front bumper was used to establish the time of first contact with the barrier structure. The impact speed of the vehicle was captured by means of an external speed trap.

All the data from the laboratory instrumentation were sampled over 400 ms, and subsequently filtered in accordance with SAE Recommended Practice J221-1. [9] For each test vehicle, the acceleration data were integrated to provide the vehicle's change in velocity (delta-V) over each millisecond of the crash.

The equivalent accelerations recorded by the on-board EDR were retrieved from each vehicle using a Bosch Diagnostics Crash Data Retrieval tool. [10] These accelerations were integrated to produce the vehicle's changes in velocity in 1 ms time intervals for comparison with the above-noted values.

Test No.	Test Vehicle	Test Speed (km/h)	Initial Speed		
			EDR (km/h)	Difference (km/h)	Difference (%)
TC09-203	2009 Dodge Journey	40.19	40	-0.19	-0.47
TC09-126	2009 Dodge Journey	47.90	46	-1.90	-3.97
TC07-218	2007 Jeep Compass	47.84	47	-0.84	-1.76
TC07-116	2007 Jeep Compass	56.12	55	-1.12	-2.00
TC08-131	2008 Dodge Avenger	47.80	48	0.20	0.42
TC09-125	2009 Chrysler Aspen	47.69	47	-0.69	-1.45
TC09-127	2009 Dodge Ram	47.66	47	-0.66	-1.38
			Average	-0.74	-1.51

**Figure 8. Comparison of Initial Vehicle Speeds**

## Crash Test Results

### Initial Speed

In Figure 8, the initial speed for each test vehicle as measured by the laboratory's speed trap, is compared against the pre-impact speed, at  $t = -0.1$  s or  $t = -0.2$  s as available, from the pre-crash data captured by the EDR. Note that the EDR's report speeds as integer values.

In all cases, the EDR-reported speed is within 2 km/h (4%) of the actual impact speed. On average, the speeds recorded by the EDR differ by only -0.74 km/h (-1.51%).

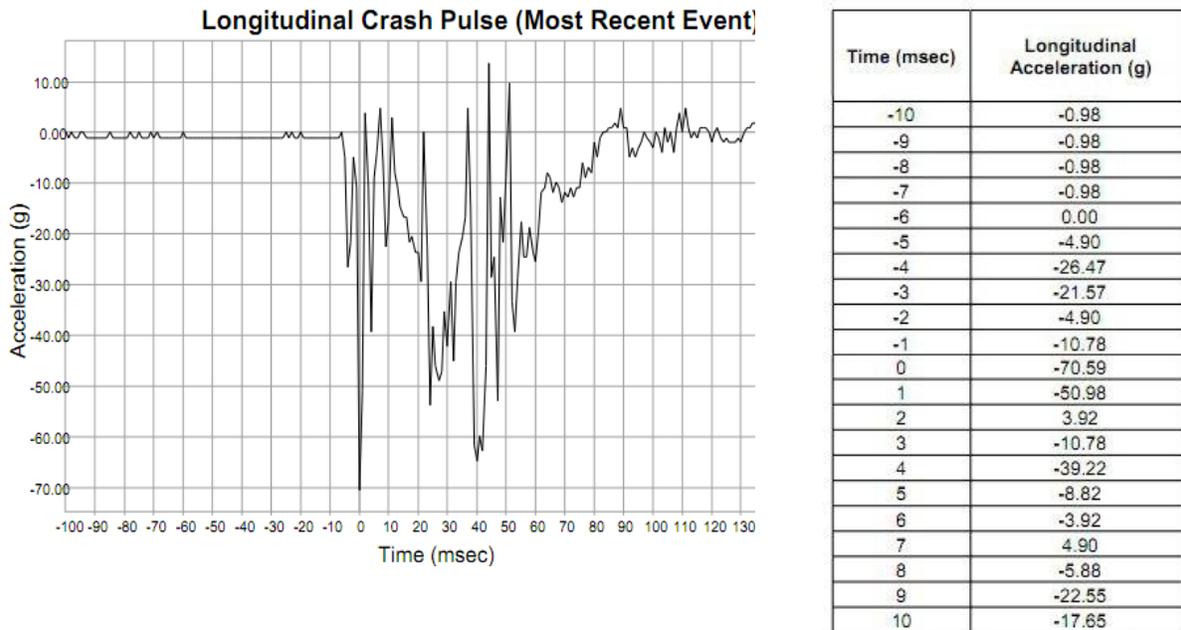
### Delta-V

In the following charts, the vehicle's delta-V computed from the accelerometer installed at the vehicle's centre of gravity is annotated in the form TC09\_203\_CG\_DV, where TC09\_203 refers to the number assigned to a specific crash test. Similarly, the delta-V computed from the accelerometer mounted at the left-side B-pillar is designated as TC09\_203\_LS\_DV, and that from the accelerometer mounted at the right-side B-pillar as TC09\_203\_RS\_DV.

The delta-V's were also calculated by integrating the acceleration profiles obtained from the EDR's. In general, these results are annotated in the form TC09\_203\_EDR\_DV. For the 2009 Dodge Journey (Test Nos. TC09-203 and TC09-126), that is equipped with the Continental module, the acceleration values start (t = 1ms) close to algorithm wakeup and continue over a further 250 ms. With no other timing information, the plots are constructed solely on this basis.

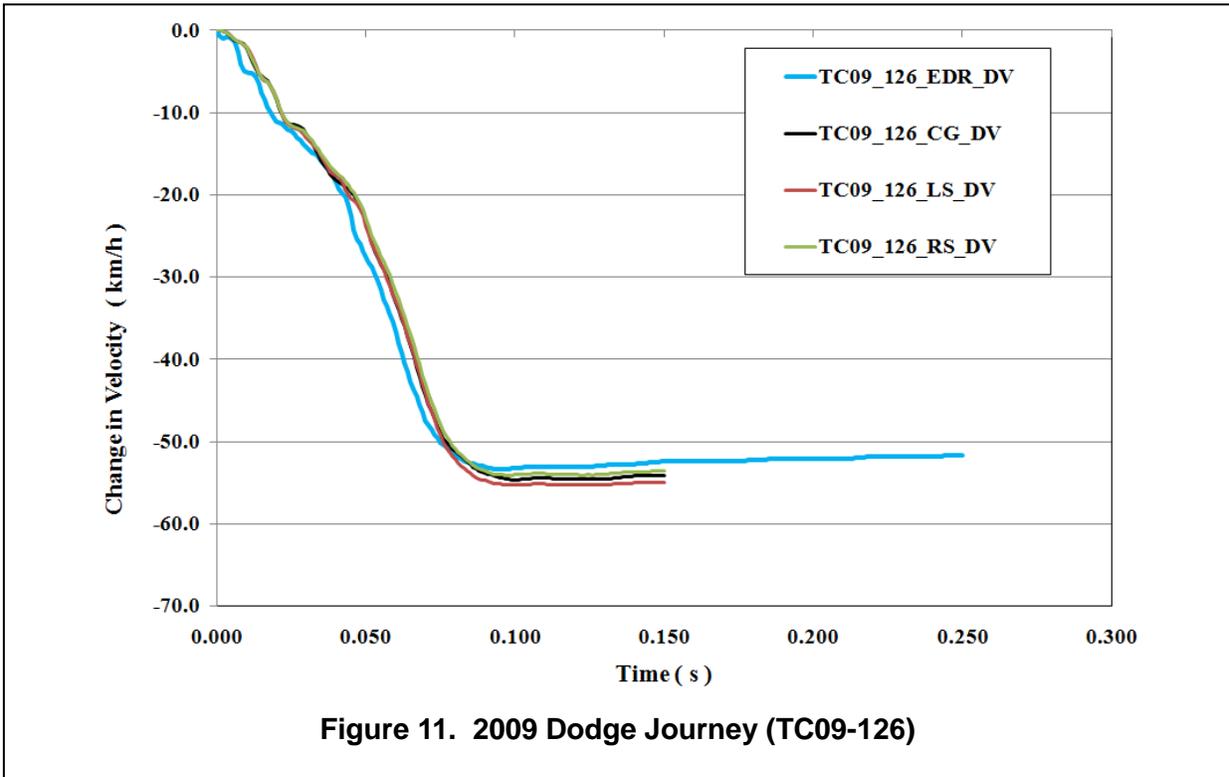
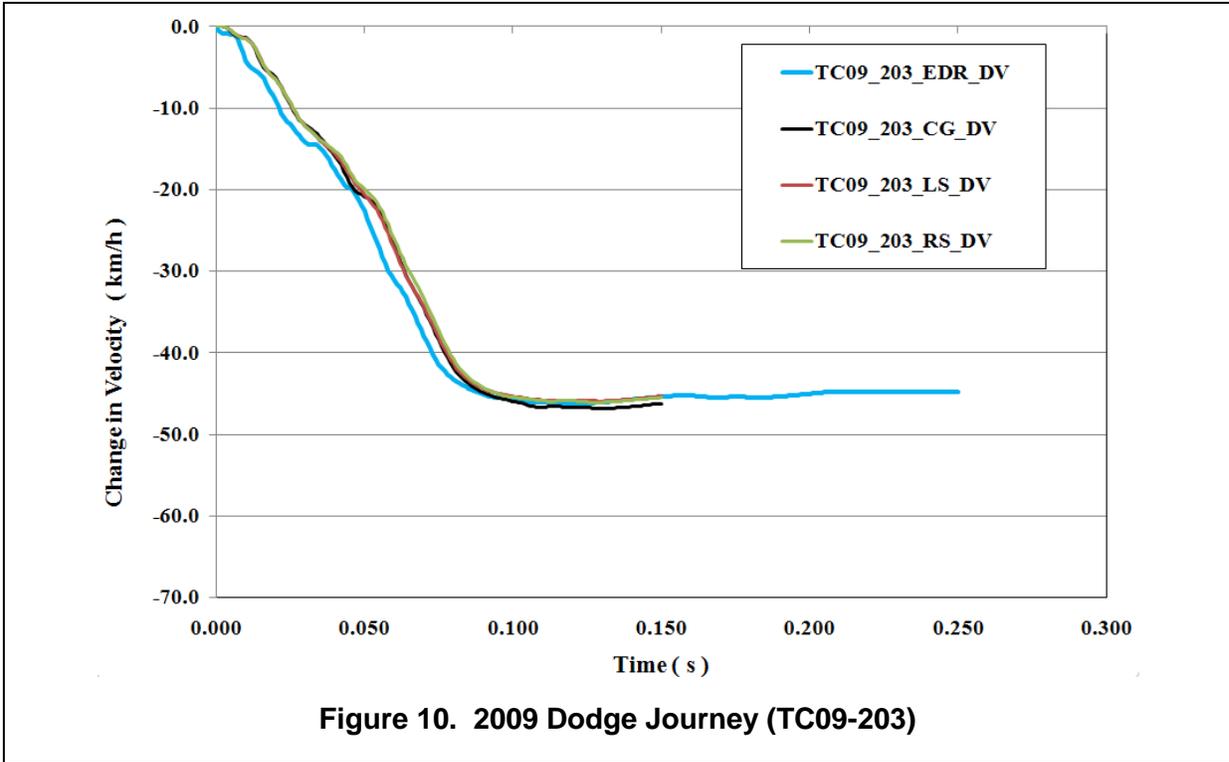
However, in the case of vehicles equipped with TRW modules, acceleration data are available for approximately 100 ms prior to the vehicle striking the barrier. These pre-impact acceleration data afford an opportunity to select a different value for time-zero (t = 0) than that indicated by the EDR.

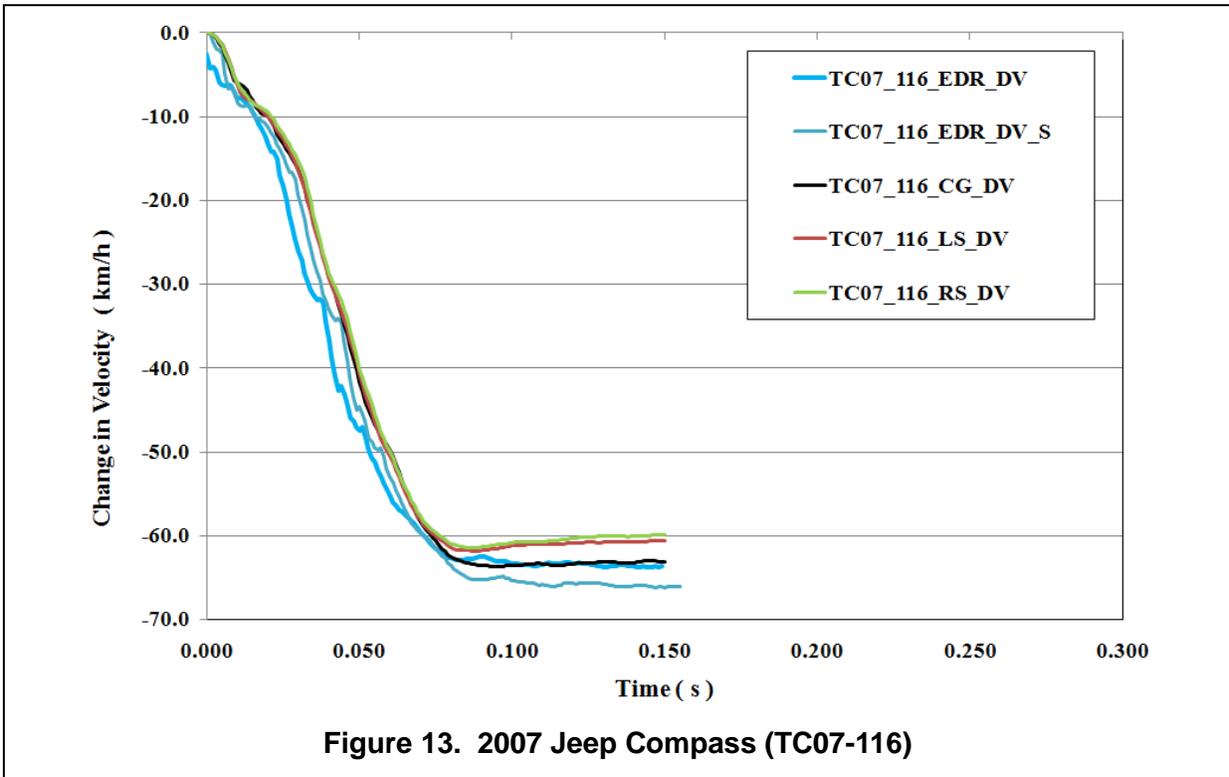
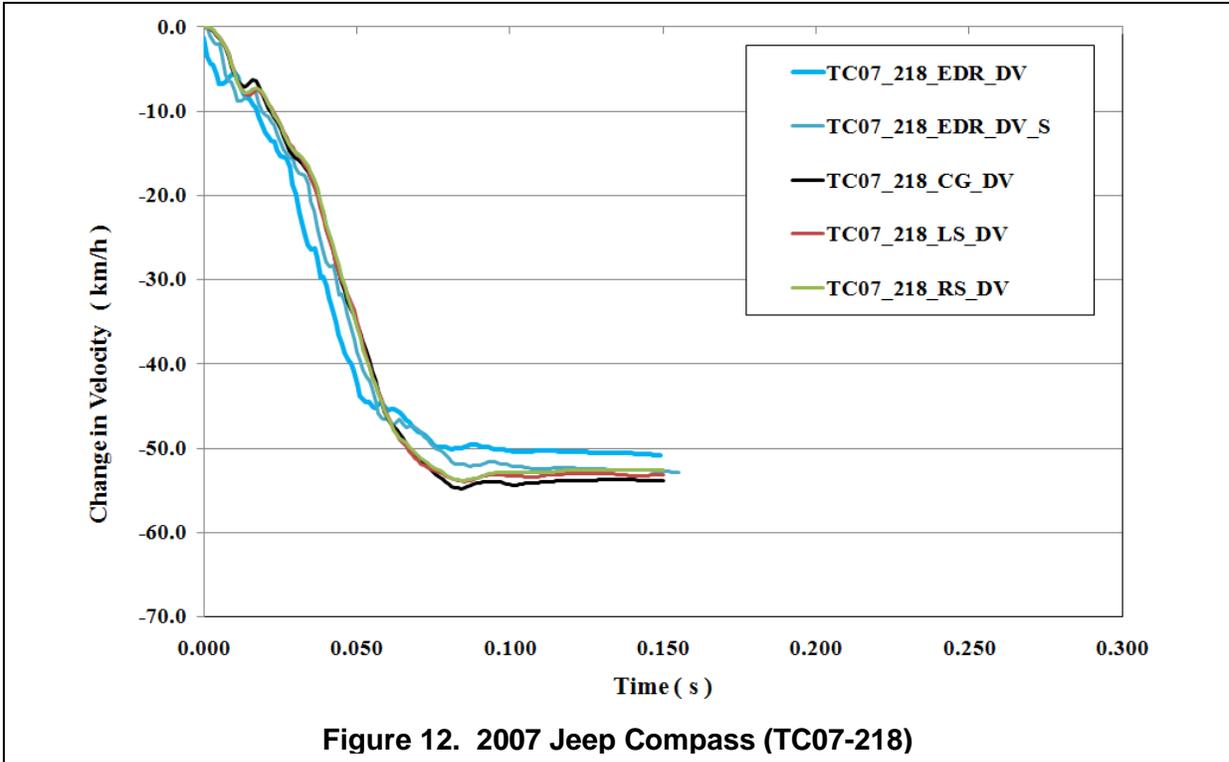
For example, in Figure 9 (Test No. TC07-116) the accelerations that were recorded before the EDR's t = 0 can be seen. After remaining between 0 and -1 g for some time, the acceleration abruptly goes to -4.90 g at t = -5 ms, and subsequently to -26.47 g at t = -4 ms. These specific values are obtained from the tabular data (extract shown below) that are associated with the acceleration plot and which are included in the crash data retrieval report. Consequently, in this instance, a time shift of 6 ms was introduced into the EDR data.

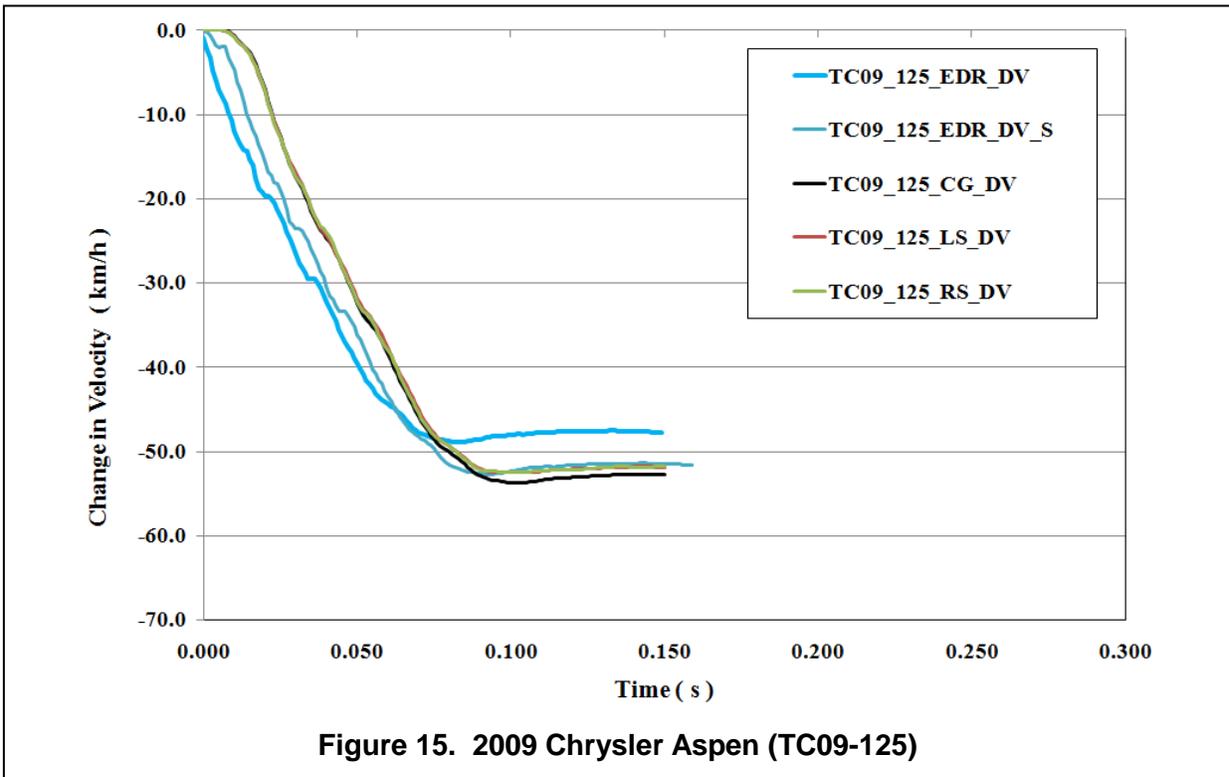
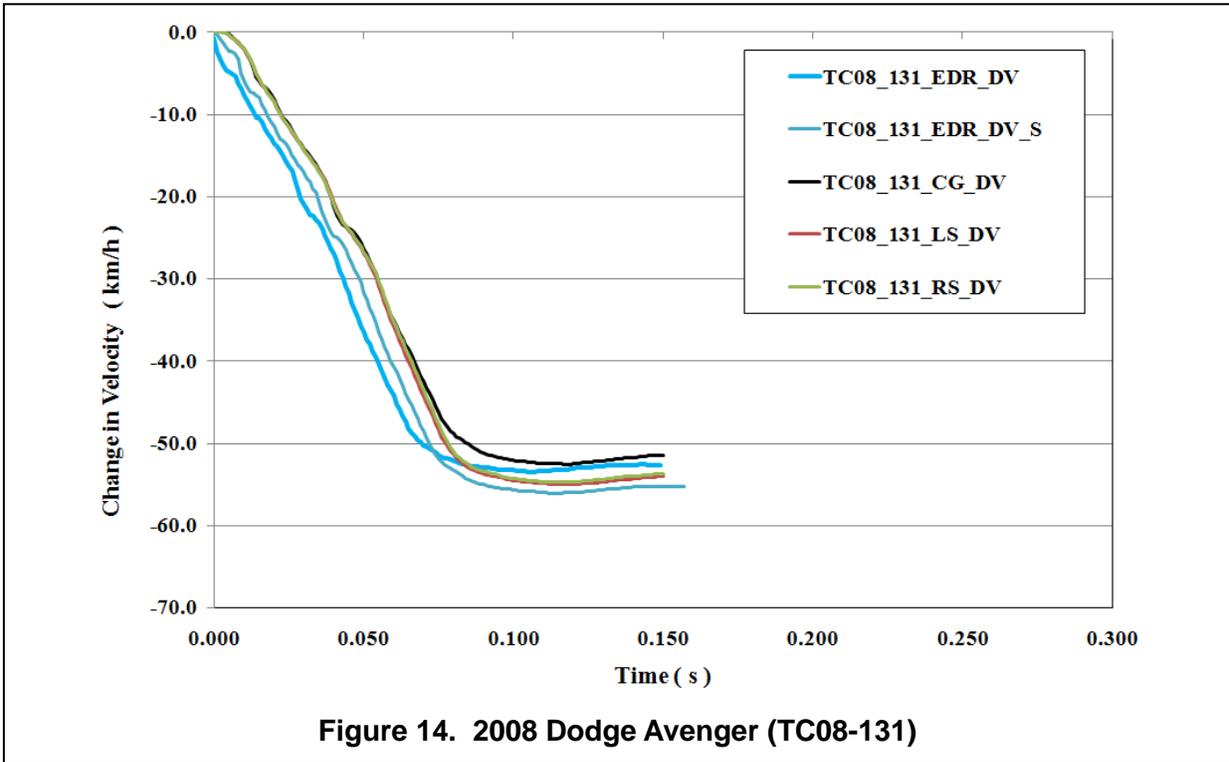


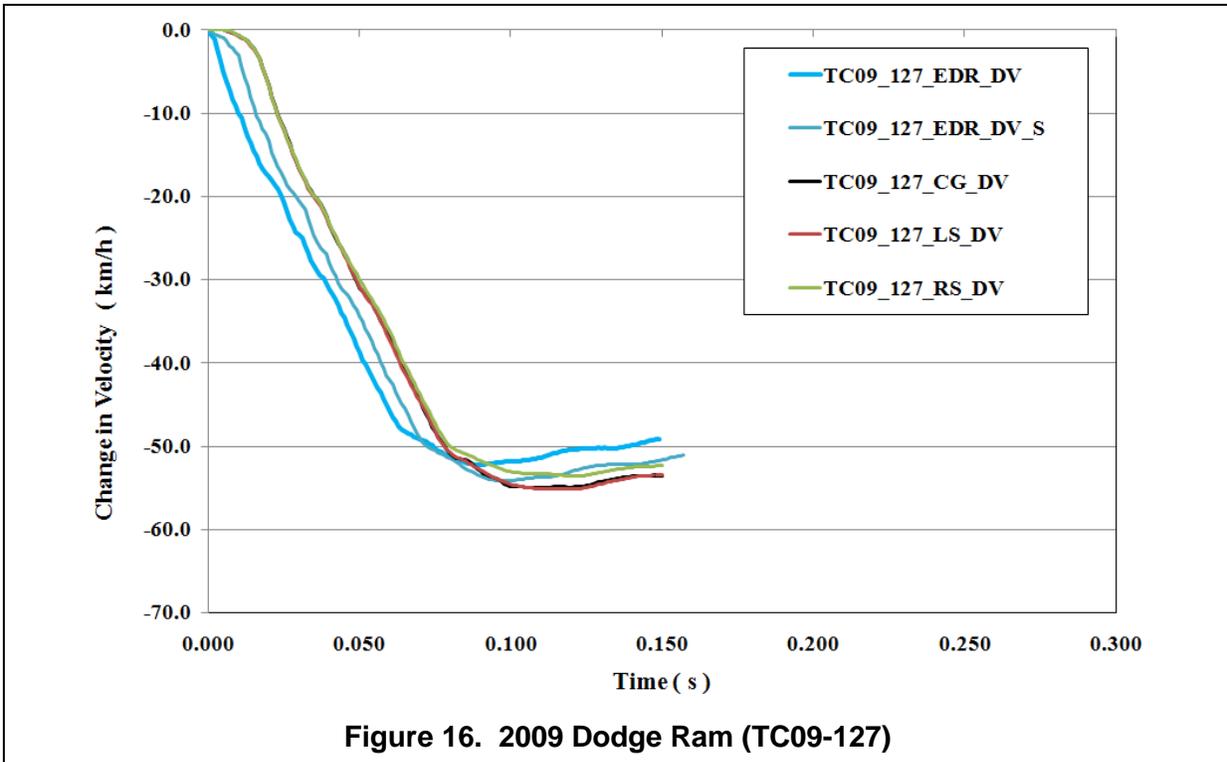
**Figure 9. Crash Pulse Data from a 2007 Jeep Compass (TC07-116)**

Using the above-noted methodology, two sets of delta-V values are provided for applicable tests. For example, in Figure 13, the graph marked TC07\_116\_EDR\_DV shows the delta-V as calculated with respect to the time-zero (t = 0) data point obtained directly from the EDR readout. The second plot, marked TC07\_116\_EDR\_DV\_S, is the delta-V calculated after employing a 6 ms time shift.









Test No.	Test Vehicle	Test Speed (km/h)	Delta-V Laboratory (km/h)	Delta-V EDR (km/h)	Difference (km/h)	Difference (%)
TC09-203	2009 Dodge Journey	40.19	-46.82	-46.21	-0.61	-1.30
TC09-126	2009 Dodge Journey	47.90	-54.60	-53.34	-1.27	-2.32
TC07-218	2007 Jeep Compass	47.84	-54.73	-52.85	-1.87	-3.42
TC07-116	2007 Jeep Compass	56.12	-63.69	-66.14	2.45	3.85
TC08-131	2008 Dodge Avenger	47.80	-52.51	-56.11	3.59	6.85
TC09-125	2009 Chrysler Aspen	47.69	-53.71	-52.71	-1.00	-1.86
TC09-127	2009 Dodge Ram	47.66	-55.03	-54.17	-0.87	-1.57
Average					0.06	0.03

**Figure 17. Comparison of Calculated Delta-V's**

As can be seen in the table shown in Figure 9, the use of the time-shifted data introduces a number of additional acceleration values into the integration procedure, and thus increases the value of delta-V that is calculated.

The shapes of the delta-V plots in all of the foregoing figures, and the range of values, are quite consistent between the results calculated from data captured the laboratory instrumentation and those recorded by the vehicle EDR's. Some time-shifting of the curves from the EDR data is evident, even when accommodation has been made through the use of pre-impact acceleration data where these were available.

As shown in Figure 17, the values of delta-V calculated for the two datasets were in good agreement. The delta-V's calculated based on data retrieved from the EDR's were, on average, within 0.06 km/h (0.03%) of those calculated from the test centre's data. The actual differences ranged from -1.87 km/h (-3.42%) to 3.59 km/h (6.85%).

## Conclusions

The pre-crash speeds recorded by the EDR's differed from those measured by the laboratory instrumentation by no more than 2 km/h for the Dodge Journey, and by just over 1 km/h for the other models tested. These differences are close to the tolerances specified by Chrysler.

The changes in velocities calculated from the acceleration data captured by the EDR's installed in the vehicles tested were close to those obtained from the laboratory accelerometers mounted at the vehicles' centre of gravity. On average, the delta-V's obtained from the EDR were within 0.06 km/h (0.03%) of those calculated from the test centre's data. The actual differences ranged from -1.87 km/h (-3.42%) to 3.59 km/h (6.85%).

The variability in the results obtained for individual EDR's is mirrored to some extent by variability observed between the three accelerometers used by the test centre. In some instances, the differences between the delta-V's calculated for the individual accelerometers were of the same order of magnitude as those seen between the EDR-based result and that obtained from the accelerometer at the vehicle's centre of gravity.

The time-shift phenomenon, where the EDR-based delta-V plots do not precisely overlay those developed from the laboratory data, was evident to a small extent in all of the tests. The introduction of a time shift for time-zero, based on the pre-impact acceleration values recorded by the EDR's in some vehicle models, had a positive effect in matching the curves.

The time-shifted delta-V profile generally provided closer agreement with the delta-V profile calculated from the laboratory data and suggests that this may be a useful technique, even for field data, in cases where the onset of the crash pulse can be clearly identified.

Overall, the results from the series of crash tests undertaken in this study, for a number of different vehicle models, and with a number of different initial speeds, indicate that end users of the output from Chrysler EDR's can have some confidence in the accuracy of these data.

## Acknowledgements and Disclaimer

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The opinions, findings and conclusions expressed in this paper are solely those of the authors and do not necessarily represent the views and/or policies of Transport Canada.

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